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Periodic Ceramic-Polymer Shell-Network of High Specific Stiffness

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The demand of lightweight materials as building blocks in applications that require a combination of high stiffness and low density emerges the need of exploiting the extraordinary properties of composite structures in the micrometer scale. Towards this end, composite shellular structures consisting of a architected polymer skeleton and a thin coating of alumina are fabricated and tested under uniaxial mechanical compression with the use of a custom-made displacement-controlled device. The results of the mechanical compression of the composite structures have shown a stiffness scaling with the alumina coating thickness being significantly higher compared to the compression results on the pure polymeric structures. Taking into advantage the unique optimized architecture of the structures and the beneficial contribution of the alumina in the microscale, this work shows, that with an increase of only 1% in density, an increase in the strength of 230% is achieved by adding only a 50 nm thick coating of alumina on the polymeric shellular structures. Such results place the optimized composite structures designed in this work on the blank space on an Ashby chart as shown in Figure 1, pushing the limits of the low-density high-strength end of the already known materials.

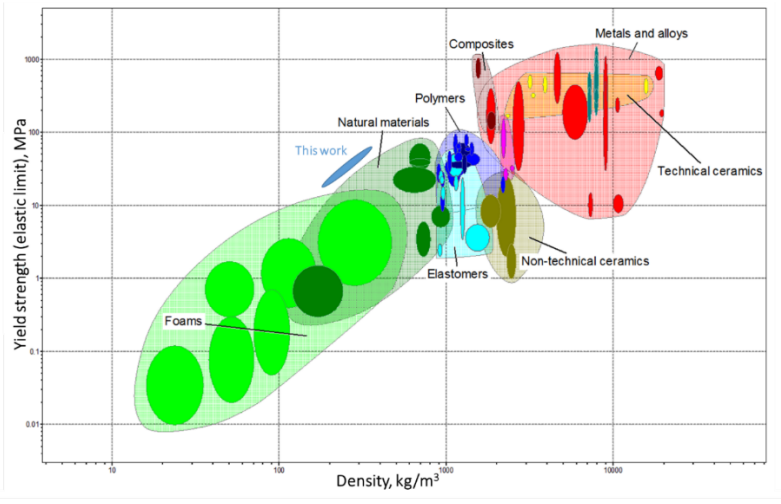

Figure 1. Ashby chart of the yield strength as a function of the density showing the high stiffness and the low density.

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